

a woven fabric with a biased stretchability, such that stretch is allowed circumferentially but is substantially constrained or disallowed vertically. In some liner garment embodiments, the proximal liner sleeve portion has a pattern of polyurethane laminated on the external surface of the elastic fabric or integrated into the elastic fabric, such that it is exposed on the external surface. In some embodiments, the proximal liner sleeve portion includes a non-stretch webbing, applied to the internal surface or integrated into the internal surface of the fabric. Such webbing may be in the form of strips or patterns that include open spaces. In some embodiments of the liner garment, the proximal liner sleeve portion includes a non-stretch webbing applied to the external surface or integrated into the external surface of the fabric. In some liner garment embodiments, the proximal liner sleeve portion includes tensioning straps arranged on the external surface.

[0012] In some embodiments of the liner garment, the distal end of the liner may include an umbrella disposed on an external surface of the liner garment. Embodiments of the umbrella are generally saucer shaped and have a concave proximal surface that conforms to a convex aspect of the distal end of the garment liner. In some embodiments of the liner garment, the umbrella has a pentagonal periphery. The five points of the pentagonal shape may be arranged to be disposed over five centrally converging seams disposed at the distal end of the liner garment, the five seams forming a joining of the edges of darts in a flat pattern from which the liner garment is fabricated. In some liner garment embodiments, the umbrella has a distal surface, and a set of radiating ribs is disposed on the distal surface. This set of radiating ribs on the distal surface of the umbrella is configured to engage a complementary set of teeth and intervening slots disposed on the proximal surface of a distal funnel disposed at the distal-most aspect of a cavity of a prosthetic socket. In some umbrella embodiments, the surface area of the umbrella (and, accordingly, the surface area in contact with the liner garment embodiments) ranges between about 15.9 cm² and about 29.2 cm². In related embodiments, the surface area of the umbrella may be greater than any of 15 cm², greater than 20 cm², greater than 25 cm², or greater than 30 cm².

[0013] In some embodiments of the liner garment, the prosthetic socket includes a distal funnel disposed within a distal-most site within a central, proximal facing cavity of the prosthetic socket. In some embodiments, the distal funnel has a proximal surface with a set of teeth and intervening slots configured to complement a shape of radiating ribs disposed on a distal surface of an umbrella disposed at the distal end of the liner garment.

[0014] Some embodiments of the liner garment have a cable-based tensioning mechanism. For example, the cable based tensioning mechanism may be disposed on an external surface of the liner garment, and arranged in multiple circumferential loops there around. In some of these particular embodiments, the cable of the tensioning mechanism is enclosed in a plastic sheath, which is adhered to the external surface of the liner by one or more layers of thermoplastic. In a second example, the cable-based tensioning mechanism may be disposed within a fabric layer of the liner garment, arranged in multiple circumferential loops.

[0015] In typical embodiments of the liner garment, the distal end of the garment has a distal connection feature

configured to attach to a distal internal site within a prosthetic socket. Such distal connection feature may include an umbrella formed of thermoplastic and adherent to the distal end of liner garment, the umbrella having a distally directed feature configured to engage the distal and internal aspect of a prosthetic socket.

[0016] In another aspect, a prosthetic socket configured to accommodate a residual limb of a patient may include a prosthetic socket frame, a prosthetic socket liner garment, an umbrella bonded to a distal aspect of the liner garment, and a distal funnel. The distal funnel may be secured within the prosthetic socket frame. The umbrella and the distal funnel may be locked together in a non-rotatable manner relative to each other, thereby securing the prosthetic socket liner garment within the prosthetic socket frame in a manner that precludes rotation of the liner garment with respect to the prosthetic socket frame.

[0017] In yet another aspect of the invention, a liner garment system for a prosthetic socket is provided that is configured to accommodate a residual limb of a patient. Embodiments of the liner garment system include a main body formed by an elastic, fluid permeable material layer extending around a full circumference of the liner garment and having an inner surface, an outer surface, a closed distal end and an open proximal end for accepting the residual limb of the patient. Embodiments further include a fluid impermeable gel cup positioned on the inner surface of the main body at its distal end, wherein the gel cup is configured to accommodate a distal end of the residual limb, and the gel cup does not extend to the proximal end of the main body. Embodiments may further include at least one support material layer on a portion of the outer surface of the main body, wherein the at least one support material layer includes a material that is less elastic than the fluid permeable material layer of the main body. Embodiments further include a supportive umbrella attached to the outer surface of the distal end of the main body. And embodiments still further include a distal funnel configured for placement at a distal-most end of a cavity of the prosthetic socket, wherein the distal funnel has a proximal surface that is complementary in shape to a distal surface of the umbrella.

[0018] In some embodiments, a prosthetic liner garment may be included with a prosthetic socket device that also has a thermoplastic distal support cup disposed within the internal and distal aspect of a prosthetic socket. In particular embodiments, the distal support cup may be formed of an ethylvinylacetate-polycaprolactone (EVA-PCL) copolymer that has a thermolabile temperature low enough that it can be molded directly to the distal end of a residual limb (albeit with an optional intervening heat protective fabric) to custom mold the distal cup for the patient. In some embodiments, the distal cup and the liner garment may be bonded together. Aspects of this technology are described in U.S. patent application Ser. No. 14/659,433 of Hurley et al., as filed on Mar. 19, 2015, and in U.S. patent application Ser. No. 14/951,878 of Hurley et al., as filed on Nov. 25, 2015.

[0019] These and other aspects and embodiments are described in greater detail below, in reference to the attached drawing figures.

BRIEF DESCRIPTION OF THE FIGURES

[0020] FIG. 1 is a side perspective view of a liner garment, showing proximal and distal portions of the garment, as well